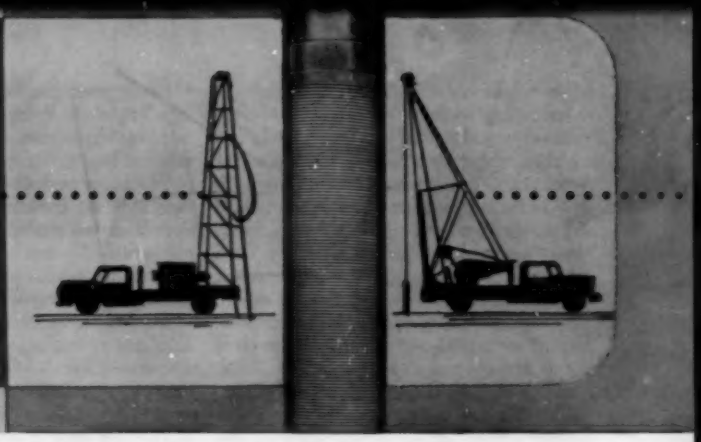
The Johnson National DRILLERS JOURNAL



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Conservation is the Key

Water for America's Farm Lands

• The following is a slightly condensed copy of one of three talks given in a panel discussion, "Adequate Water Supply for Tomorrow," at the annual meeting of the Chamber of Commerce of the United States at Washington, D. C., in May.

By Ervin L. Peterson

From the beginning of time the life of man has depended upon and been influenced by water, the most plentiful substance on earth. Through the centuries water has played a dominant part in human survival and the advancement of civilization. Ancient wells, aqueducts, and reservoirs of the old world, some still serviceable after thousands of years, attest to the attention of peoples to their water supply, its distribution and use.

Fifty centuries ago the civilization of India's Indus valley enjoyed the benefits of a well-designed water supply and drainage system, public swimming pools and baths. Excavated ruins of that period have revealed a surprising variety of water works — reservoirs, aqueducts, irrigation canals.

Opening the West

In this country our interest in water for agriculture was incidental to opening the arid western United States to settlement. Our vast public domain was of little usefulness until its rich productiveness could be unlocked through the application of water to the land. Until people could put the resources of the area to effective use, there was no way to establish homes, to build communities, schools, churches, to build a local society capable of self-government to add star after star to our flag.

The key to full development was, and *is*, water — water for farms, for cities and towns, for industry, for the generation of power, for inland navigation, for fish, wildlife, and recreation.

The Reclamation Act of June 17, 1902, did as much as, if not more than, any other single legislative enactment to build western agriculture and open a vast storehouse of riches for all our people. More than that, its application has demonstrated that natural resources can have no significance except as they are related to the needs of people.

In this nation we were blessed with a great abundance of natural resources: lands, forests, minerals, fuels, and water. At the turn of the century we began to realize that some of these resources were not inexhaustible. That early recognition led to the creation of our national forests. More than another quarter century was to pass before like recognition applied to our lands — our productive soils. Shortly thereafter we gave attention to continued availability of minerals, including fuels and particularly petroleum.

Only now have we begun to awaken to the key significance of the availability for use of adequate and clean water to the total complex of our society. We have entered the stage of competition not only for the use of water but for the right to use it. We see interstate compacts, the purpose of which is to divide

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up available water supplies among the compacting states. We see industry carefully evaluating location in relation to available water. We see great cities beset with complex problems incident to providing water for their population. We see agriculture — the nation's farmers — everywhere recognizing the need for controlled application of water through irrigation not only to assure the production of crops and pastures, but to lower unit costs. We have reached the point in our development as a nation where a paramount question is: "Who is to have water and how much?"

The forces of economic competition are at work on our water supplies. We now are beginning to recognize that water is life itself, both physical and economic. How much water is needed by industry to provide the goods, materials and services wanted and used by our people? How much water is needed by our cities and towns fully to satisfy their inhabitants? How much water is required by our farmers and ranchers to supply the foods, fibers, and materials for industrial use needed by our population?

How much will these needs be expanded by the rapid growth in our population, now estimated to exceed 210 million people by 1975?

How will our water supplies be divided up between industrial, domestic, and agricultural uses? Who will make the allocations? On what basis will the allocations be made?

What can be done to meet the increasing demands for water? Who is responsible for doing it? How will the costs of water developments be shared among the immediate users and the government? What government — federal, state, or local — and under what conditions — is to be responsible for seeing that needs are met and that allocations of water itself and of its costs between users are fair and reasonable?

What is the role of private enterprise in these problems, and how will it be affected?

We must recognize that the role of the federal government in water resource development is, and should be, cooperative — not preeminent. Every reasonable encouragement should be given for participation by private enterprise and by local and state government in water resource development. Federal responsibility should be limited to those programs which are not competitive with alternative means of obtaining effective use of our resources.

State and Local Action

While general uniformity of federal policy to secure resource development at minimum necessary cost and of greatest nationwide value is both necessary and desirable, federal policy alone is not enough. What is now needed is a *nationwide* water policy and natural resources policy within the framework of which private initiative risk capital, local and state government, and the federal government can all work in harmony and accord. A basic objective is the perpetual use of our resources in such manner and under such conditions as will assure all of us the materials needed to make life both possible and satisfying, now and for the future. Such a policy will require for its successful implementation a high degree of responsibility by all participants. One indication of responsibility is recognition that the federal treasury is not an ever-flowing fountain to be used by some at the expense of all. Our purpose is to generate wealth — not to dissipate that already generated.

There must also be recognition of the fact that ours is a union of sovereign states which have reserved to themselves all powers not delegated in our Constitution to the federal government. The states have both right and opportunity to exercise that power. But right and opportunity also require responsibility. There is increasing evidence that the states now recognize the fact that when they do not act in areas of recognized public need there is great temptation for federal action to fill the vacuum.

Ralph Bloyer of Rockford, Illinois, drilling a 4-inch screened well for a suburban home.

The states to which the Reclamation Act applies have legislation regulating the appropriation and use of water. Some of them are finding that the needs for water by an expanding population, by growing industry, and by agriculture are creating conflicts which existing statutes are incapable of resolving. Similar conflicts brought to focus by a rapid increase of interest in agricultural irrigation throughout the eastern part of our country are bringing the question of water legislation to public attention in this area also.

All federal activity and any nationwide water policy must honor fully the right of any user or appropriator of water acquired under state law. It must also recognize the authority of the states to control and regulate the use, appropriation, and distribution of water within their geographic boundaries. It must also provide the framework within which the states can resolve conflicts arising between themselves over the use of water. As a nationwide policy for water and resource development unfolds, there are also further guideposts to be set:

Each project usually has immediate effect upon the community in which it is located. Therefore, there should be continuous consultation between the

Multiple, shallow wells being pumped by suction lift to supply the sprinkler irrigation system seen in the background. System was installed by Hopeman Equipment Company in Oklahoma.

sponsors — private, local, state, federal, or combination of all — with the locally affected interests — municipal, industrial, and agricultural. This consultation should begin at the planning stage and continue through to the completion of the projects.

Need for Research

We need to know more about water and how it behaves after it falls upon the land as rain or snow. This requires research, the accelerated collection of basic data including: land and soil analyses; soils maps; and geologic, climatic, and hydrologic information. It also requires correlation and cooperation between the collecting agencies, public and private. Basic facts thus collected need to be assembled in a central place to be available to all users. They must be analyzed and evaluated in relation to their intended use. We need to recognize that the management of water begins where the rain and snow fall upon the earth; that soil and water are so closely associated that problems of soil and water use are, for resource management purposes, inseparable.

Some years ago a study in North Carolina showed the cost of filtering mud out of municipal water originating on eroding watersheds to be $27 per million gallons. By contrast, water from well-protected forest land cost $8.50 per million gallons. The need for controlling and cleaning up the nation's rivers to provide more even flows for water users by means of sound management practices on watershed lands is also demonstrable.

The Mississippi River system varies in flow from 1/6 its average annual flow to about 4 times average; the Columbia from 1/5 to 4 times; the Rio Grande from 1/1,000 to 33 times; the Gila from 1/1,000 to 278 times; and the Potomac at Washington from 1/25 to 43 times.

The Missouri River each year on the average carries 376 tons of sediment per square mile; the Colorado River as a whole 1,724 tons, but on the upper part—mostly in forest cover—108 tons; the Gila 690 tons; the Rio Grande 837 tons; the Potomac 480 tons.

The public need for proposed projects should be clearly discernible. Projects should clearly integrate with the local economy of the community or the region. Sound business principles should be applied to all aspects of projects to supply water for economic uses. Project development should be accompanied by land management practices which most contribute to conserving the maximum amount of water from the precipitation falling on the watershed tributary to the project and which are consistent with the land economics of the area. Analysis of all projects for the same purpose should be based upon identical evaluation standards, and those standards should be clearly understood by all affected interests.

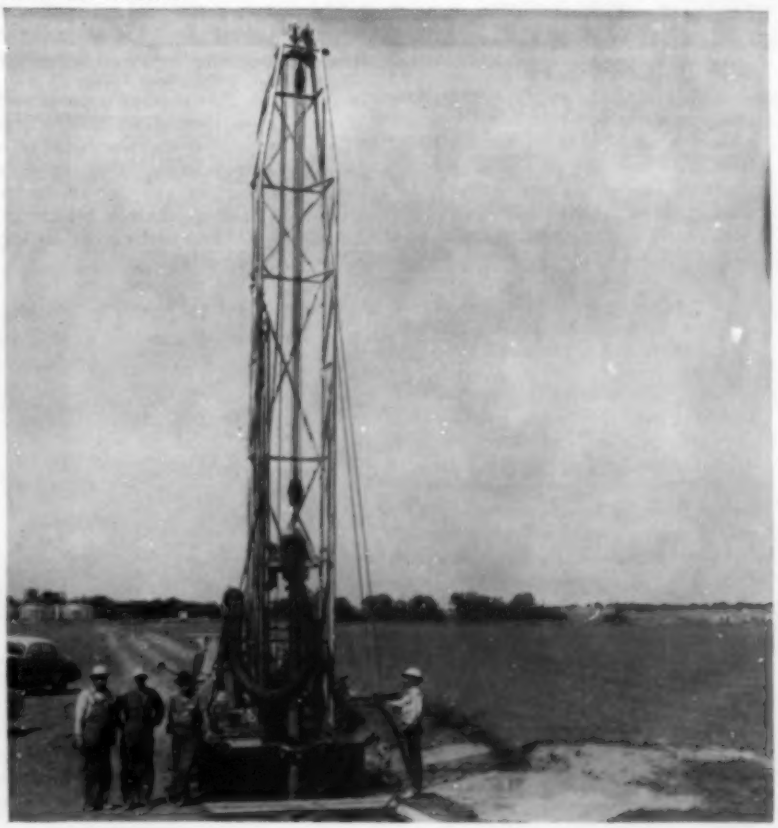
These are merely some guideposts which seem to me to make sense. There are others which need not be elaborated upon here.

Water for Agriculture

I have said that water development and water management are inseparable from land management and use. When we think of water storage, we commonly think of dams and reservoirs, when, in fact, there is more water storage capacity in the ground than in all man-made reservoirs. One problem is to get precipitation into the ground before it runs off. The forest lands of this country and their management are of particular importance in this connection. Most of the 160 million acres of national forest lands are high elevation reservoir areas of high quality. The management of our 350 million acres of farm lands assumes great importance to water conservation and use. Likewise, the 300-odd million acres in private forest lands play a very great role in water management.

While our greatest and least expensive storage reservoir is the earth itself, we will continue to need man-made storage as well. We can no longer afford to permit water to go to waste where it is feasible to hold it and put it to use. Storage and distribution works become even more important in the light of expanding needs. It should also be observed that today's planning does not result in usable facilities for some years. We must continue to move ahead with construction of water storage and distribution facilities in order to use our total resources wisely and efficiently and in order to be prepared to meet increas-

Reverse-circulation, rotary drill operated by A. R. Ewbank and his three sons of Fairview, Oklahoma. Here they are drilling a 36-inch diameter, gravel-packed irrigation well. The machine will drill up to 48-inch holes. Mr. Ewbank uses Johnson Well Screens extensively in irrigation wells in the terrace deposits of Oklahoma. Excellent yields are obtained from wells of limited depth with Johnson Screens 8 to 12 feet long. One well near Greenfield, Oklahoma, with a 12-inch Johnson Screen only five feet long was tested at 1,100 gpm and is in service at 800 gpm with 18 feet drawdown.



ing demands as they develop.

The purpose of these remarks so far has been to point up the fact that water for agriculture is inseparable from water for other uses. The same broad policies apply to programs for water for agricultural use as apply to programs for water for other uses. In fact, many projects and programs are multipurpose in concept, design, and management.

Agriculture is, in fact, a competitor with other users of water. Agriculture's representatives need to understand, evaluate, and relate agriculture's interests to the total interest in water, its development, management and use. In fact, agricultural policy does and will continue to affect water policy as well as the physical development, management, and use of water, for water and land cannot be separated. Water falls upon the land and is either soaked up, stored, or runs off.

Need for Water

Now what is agriculture's need for water? Or perhaps a better wording is: What is the nation's need for agriculture?

First, we now have 165 million people to feed and clothe. It is estimated that our population will be about 178 million just 5 years from now, in 1960. Further projections indicate a population of 210 and possibly 220 million persons by 1975. In addition, we expect to retain and add to our foreign markets for agricultural commodities.

Now, what is our production base? Over three decades ago we reached a cropland base of approximately 350 million acres. That base has never been significantly exceeded, nor is it likely to be in the near future. As new land has been brought to production, other land has gone out of production by abandonment, for industrial and urban expansion, for development of suburban areas, highways, airports, and for other assorted uses. For the foreseeable future we must produce our foods, fibers, and agricultural products for industrial use on cropland now in use.

How have we been able then to have such abundance of food these past 35 years as to require, in this year 1955, restriction of production for some crops? First, about 75 million additional acres became available for food production with the disappearance of more than 20 million head of horses and mules. Agriculture became mechanized. Crops produced for export a little over three decades ago used approximately 60 million acres of cropland as against some 40 million acres or less in more recent years.

A second and more significant fact has been the increased crop yields per acre and higher yields of food from improved livestock, including poultry. The application of knowledge acquired from the research laboratories and the experiment stations, the increased productivity per man-hour of labor; in fact, the whole technological revolution which has taken and continues to take place in agriculture, increased production 43 per cent from 1940 to 1954 alone.

Competent authorities maintain that any program to increase per acre yield of crops in the humid area of our country — that part generally east of the Mississippi River — must include irrigation. To produce a bushel of corn requires about 10,000 gal. of water, a bushel of oats about 7,000 gal., a ton of cured alfalfa hay about 200,000 gal.

As improved seed is used, as increased amounts of fertilizer are applied, as better growing practices are adopted, the need for water goes up. For example, reports indicate that at Blacksburg, Va., rainfall during the past 56 years has been adequate to produce 25 bushels of corn per acre every year except two. This same rainfall would have been adequate to produce 75 bushels per acre only about half of those years. Yet as a result of application of known farming methods to growing corn, 75 bushels per acre is considered the potential production figure if water is available. This example repeats itself in some form throughout the country. Thus, water supply and not fertilizer or lack of knowledge is the important limiting factor to any significant increase in food production which will ultimately be required by a growing nation.

Total withdrawal of water in the United States for all uses is estimated to have doubled every 25 years since 1900. It is thought that the total water supply will need to be doubled again in the 1940-1975 period. If this proves to be the case, extensive further development of supplies will be urgently required.

"Didn't you install mother's safety belt a little high?"

Currently agriculture is moving forward on two fronts of great importance. On the one hand other resources are being substituted for landpower and technology. The increases in mechanical power, the expanded uses of fertilizer and pesticides, the improved crop varieties, and other technological changes have made possible our increased capacity to produce without the use or development of vast additional acreages which are unobtainable. As this vertical frontier of science is further penetrated, it will continue to make a major contribution toward providing the food, fibers, and materials for industrial use necessary for our growing population. For the maximum contribution to be made there must be developed additional water to be used by agriculture. This mechanical and technological revolution in agriculture has also been taking place in transportation, processing, and distribution.

Our costs of doing business have increased substantially. The application of the findings of science, assisted by available water, keep these costs within the capacity of producers to carry while earning incomes necessary to maintaining our high standards of living. That is why farm leadership has placed increased emphasis on efficiency of production and distribution and on the wise use of our agricultural resources. As we achieve greater efficiency in the use of land, labor, and capital, our costs will come down to the benefit of ourselves and those who use our products. That is why we are now approaching conservation, not just for conservation's sake, but with the purpose and objective of obtaining a fuller and more rewarding life for those of us who are on the land as well as those of us who depend on the resources from the land.

We have come to recognize that the end purpose of conservation is the welfare of the people, both present and future. There is rapidly developing a greater teamwork in our approach to problems of conservation. This is particularly true with respect to water developments. All of us as individuals, as organizations, as government have a proper place to play on this team. All interests, private, local, state, and federal must work together to develop a strong, prosperous, stable, and free America.

Locate Waste Dumps with Care

Sanitary landfills can pose potential threats of ground water pollution under certain conditions.

Do waste dumps in and around cities pollute ground water in underlying sand and gravel aquifers? If so, where should dump sites be located to prevent any bad effects on ground water quality?

Growing population around metropolitan areas and the need for more places for waste dumps have made these questions of some concern in concentrated areas that depend on wells for safe water supplies. They should be of special concern to well drilling contractors, for once an aquifer is contaminated, it may take years to restore its sanitary quality. In California, where a large proportion of the water supply is taken from underground basins, an extensive study of possible ground water pollution from dumps (sanitary landfills) was made in 1952 and 1953.

Riverside Investigation

The sanitary landfill owned by the city of Riverside was used as the site for this field of investigation. This dump has been in existence for 30 to 35 years. Sanitary landfills usually include incinerator-ash, garbage, rubbish, and industrial refuse. Rainfall percolating down through the fill or movement of ground water through the bottom of the dump area can carry polluting substances into the aquifer. The California study shows to what extent this might take place.

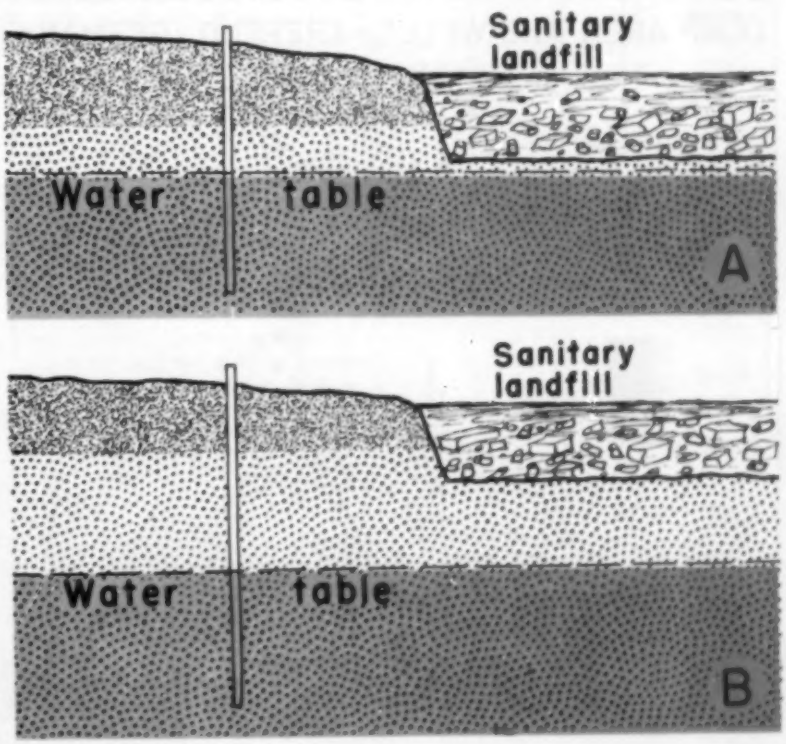
Immediately below the sanitary landfill at Riverside there are 10 to 12 feet of medium to coarse sand. A stratum of silt and clay underlies this sand but because it is not continuous it cannot be considered an impervious layer. A thick sand formation extends below the silt and clay to a considerable depth.

Samples of water, taken periodically from 30 to 35 wells, were tested to determine the degree of pollution at various depths and in various directions from the dump. The following conclusions are extracted from the report of the investigation made by the University of Southern California at Riverside for the State Water Pollution Control Board.

Results of Investigation

1. A sanitary landfill, if located so that no portion of it intercepts ground water, will not cause impairment of the ground water for either domestic or irrigation use.
2. A sanitary landfill, if located so as to be in intermittent or continuous contact with ground water, will cause the ground water in the immediate vicinity of the landfill to become grossly polluted and unfit for domestic or irrigation use. Concentration of mineral elements varying from 20 times those commonly found in the unpolluted ground water up to 10,000 times in the case of ammonia nitrogen are possible.
3. It may be expected that continuous leaching of an acre-foot of sanitary landfill will result in a minimum extraction of approximately 1.5 tons of sodium plus potassium, 1.0 tons of calcium plus magnesium, 0.91 tons of chloride, 0.23 tons of sulfate and 3.9 tons of bicarbonate. Leaching of these quantities would take place in less than one year. Removals would continue with subsequent years, but at a very slow rate.
4. Dissolved mineral matter, carried into the ground water as a result of intermittent and partial contact of a sanitary landfill with an underlying ground water, will
   (a) travel readily in the direction of flow,
   (b) diffuse vertically to a limited extent and, where the aquifer is of appreciable thickness (100 feet or more), the bottom water will probably remain unpolluted,
   (c) become diluted, which will minimize the effect of the polluted seepage.
5. Where the ground water contamination is light by reason of a sanitary landfill being in intermittent and partial contact with the underlying

Figure 1. When the water table is close to the bottom of a sanitary landfill, as in diagram A, pollution of the ground water can be expected. Diagram B illustrates a much safer condition.



ground water, the most serious damage to the ground water as little as a half-mile downstream from the landfill will be an increase in hardness, and then only in the upper portions of the aquifer.

6. Rainfall alone in this area will not penetrate a 7.5-foot thick landfill sufficiently to cause leaching into the underlying ground water.
7. Additional hardness which may result from the dissolving of calcium carbonate by carbon dioxide produced within the fill is negligible as compared to the hardness caused by leaching from the fill, unless the aquifer is of a calcareous nature.
8. Anaerobic conditions with production of combustible gas will exist within a sanitary landfill in approximately one month following dumping of the fill. The composition of the gas at that time will be composed of about 70 per cent methane and 30 per cent carbon dioxide.

German Experience

An investigation of the pollution of ground water by a garbage dump during a period of 18 years was made in 1950 near Krefeld, Germany. Figure 2 shows the location of the dump and various industrial and municipal wells in the area. The experience in this situation was reported as follows:

The ground water in this area, near Krefeld, Germany, is found in two layers, one at 30 to 36 feet, and the other at 45 to 120 feet, separated by an impervious clay layer. The uncontaminated waters from the two layers are of different chemical compositions.

Water from the upper stratum is supplied to the local population by municipal wells, through pumping station W installed in 1873, and to industries A, B, C and D by private wells. Industry E uses water from the lower stratum. The wells of industries B, C and D using water from the upper stratum were installed in 1911 and 1912.

Garbage Dumping

In 1913, the dumping of garbage was begun in an area downstream from the municipal wells, and upstream from the industries. In one part of the dump was an exhausted gravel pit in which ground water was exposed, and into which some garbage was dumped. By 1929, approximately 65,000 cubic yards of garbage had been dumped in this area.

In 1923 a deterioration of water was observed at industries A and B which were $\frac{5}{8}$ and $2\frac{1}{2}$ miles, respectively, downstream from the dump. In 1926 a deterioration of the water of industry C, $2\frac{1}{2}$ miles downstream, was observed. Deterioration of the water of industries D and E began in 1927. These industries were 3 and $4\frac{3}{4}$ miles from the dump, respectively, and in a direction diagonal to the direction of ground water flow.

The period of contamination lasted from eight years in the case of industry E, which used only water from the lower stratum, to 18 years in the case of industry A, which used only water from the upper stratum. The municipal supply was not affected during this period, and was used as a control to determine the degree of pollution of the other supplies.

The maximum total hardness varied from 600 to 900 ppm in the polluted wells compared to 225 ppm in the water of pumping station W. The water of the lower stratum, used by industry E, was of poorest quality, showing the above noted maximum hardness. The sulfate and chloride concentrations also increased in all wells, reaching maximums of 595 and 263 ppm, respectively. Iron, manganese and ammonia were found only in traces.

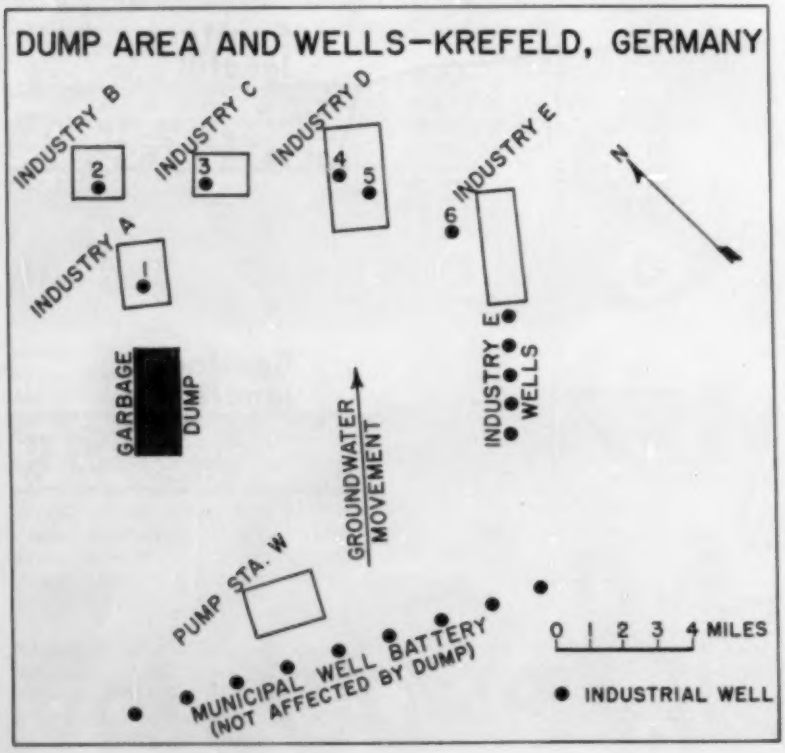
Bacteriological examination of the wells of industries C and D at the time of the greatest pollution showed only two to three cells per cc. The coliform test was negative, and believed due to the filtering action of the water-bearing sand.

High Water Table

The contamination of the ground water was more rapid because of the fact that garbage was dumped directly into the ground water in the gravel pit. Had the excavation not proceeded to the ground water, the hardening would not have been observed until years later. The high degree of hardness would not have been observed and the effect would have been distributed over many years or even decades. Thus, in individual wells, the hardness was distributed over two decades, on an average.

The experiments show definitely what influence garbage and rubbish dumps can exert on ground water, probably decades later. The use of caution in the location of garbage dumps is thoroughly justified.

Figure 2. Diagram showing the industrial and municipal wells at Krefeld, Germany, in relation to the location of the waste dump. Note the direction of ground water movement.



Abstracted by permission of the State Water Pollution Control Board from a report on the "Investigation of Leaching of a Sanitary Landfill" by Prof. Robert C. Merz, University of Southern California. German experience at Krefeld translated by Dr. Raymond Zehnpfennig from "Influence of Garbage and Rubbish Dumps on Ground Water" by B. Roessler in "Vom Wasser," 1950.

TOM'S COLUMN

This time my story is about how we fixed up a well that went bad, and did it in a pretty easy way that might fit one of your jobs some day.

We drilled this well back in 1920. It was our first big job of this kind. I'll never forget it any more than any well driller forgets th' first job he takes that can break him if it goes wrong or help him climb up higher on th' ladder if it comes out good.

It was put down for a big canning company that had plants all over the country — three of 'em in my area. I was awful anxious to get their work, and I lived on that job almost night an' day.

We ran a 24-inch OD casin' down 105 feet to limestone to case out th' shallow stuff. We drilled a full hole on down through th' limestone and through a soft sandstone to 326 feet. The sandstone wanted to cave a little and gave us some trouble.

Below this soft sandstone we hit shale that got real hard when we were into it about 20 feet. We landed a string o' 16-inch OD pipe as a liner and cemented it in all th' way from 326 feet to th' surface.

Hit Hard Sandstone

Then we drilled open hole through th' shale an' into a hard sandstone which had a poor yield of water, very hard an' full of iron. I think this water ran about 25 to 30 grains hard and eight or ten parts of iron. Below this was another limestone with big openings in it. Our bit would drop two feet in some spots as we went through it.

While drillin' these formations th' water level stood at about 180 feet from th' surface. Th' limestone got harder an' tighter until th' last 50 or 60 feet were almost as hard as drillin' granite. From this we passed into a few feet o' broken, jumbled-up stuff and then, at about 980 feet, got into th' formation we were after — a sandstone with nice soft water.

We drilled 20 feet into this, set a 12-inch liner up to th' surface an' cemented it in as best we could. We figured we were cemented in solid up about 100 feet from th' bottom end of th' 12-inch. A lot of excess cement just disappeared in th' limestone channels further up.

We drilled down to 1,140 feet an' finished her up there. We cut off our 12-inch at 165 feet, an' th' well was done. It's been a good well for 35 years, and all we've done to it has been pump work. It's not a high yieldin' well, but th' water has been good quality — that is, until this winter. Then they noticed it was changin'. They ran an analysis on th' water and it was twice as hard as it was originally an' the iron was up to about two ppm.

Corroded Liner

Well, we pulled th' pump an' went into 'th well. It wasn't much of a trick to find th' trouble. Th' 12-inch liner had corroded all th' way through in several places between 175 feet and 200 feet down. This let the bad water from above come into th' well. The next thing was to give them a straight steer on what they ought to do.

Here was a well that was 35 years old. It didn't owe them a dime if they abandoned it. But outside o' this one bad place in th' casing it seemed like there was a few more good years left in th' well. We ran down a perforator an' put in three or four slits in th' 12-inch down below 210 feet an' there seemed to be a pretty fair wall left in it.

Here's what we did. We ran our inside casing cutter in th' 12-inch and cut it off as close above a joint as we dared to, right at 245 feet. When we brought up th' 80 feet of pipe we had cut off we found at least 100 holes through it in the section that had set between 175 feet and 210 feet — one as big as a quarter an' th' rest runnin' down to tiny pinholes. Where th' cut was made I'd say th' pipe had from ⅛ inch to as much as ¼ inch of good metal left.

Clean Cut Is Made

Our soap impression block to check th' top of th' 12-inch showed it was a pretty clean cut. A little egg-shaped, but almost perfectly centered in th' hole.

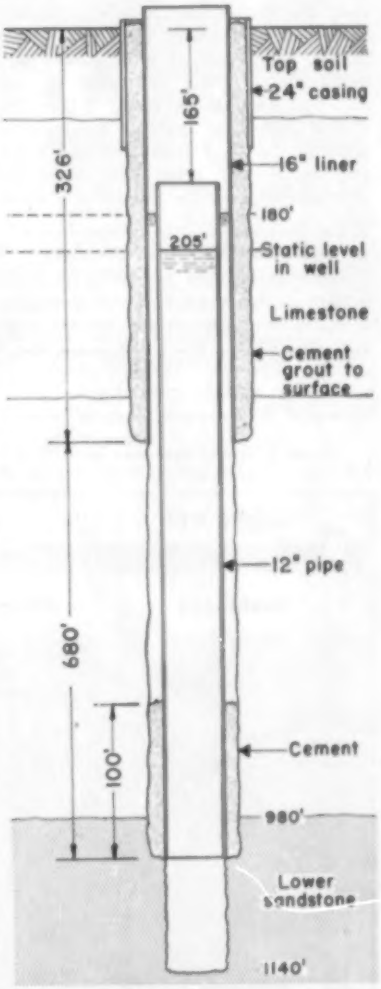
Then we had the Johnson company make us one of their drive packers. It was made on a 4-foot piece of 10-inch pipe with a 12-inch coupling welded on top. They cast a lead jacket on this 10-inch pipe, taperin' from about 12½-inch diameter at the top down to the OD of the 10-inch at the bottom.

We lowered this down on a string of 12-inch pipe until we eased it into place in th' old 12-inch liner down in th' well. When we loosened our line th' string settled down maybe an inch or so from th' weight. Then we drove it light and easy until we could tell it was tight. Had to be careful not to split th' old 12-inch. We went inside to check for a leak and it was bone-dry down to th' deep water level. We centered th' 12-inch at th' surface, cut off, an' called it a job. There won't be a drop ever come past that packer. It's as tight as a cork in a champagne bottle!

Well, I thought you might find this little story to be of some interest to you, an' you might run into a spot some day where a drive packer will save th' day. I've used several of them, an' when they're made right an' put down right they do a good job. An' it's doin' a good job that brings you customers!

Yer ol' friend,

Tom



Sandstone well as originally constructed. Later, holes in 12-inch liner were found at 175-ft. to 210-ft. levels. The 12-inch pipe was cut off at 245 feet and drive packer installed at that point to effect repair.

Hydraulic Principles Involved

Factors Affecting Well Yield

• *This is the first part of a two-part article on well yield and drawdown.*

The yield of a completed well is probably the most important single item of interest to the well driller. In most cases, the yield will determine whether or not the well is a success or a failure in the eyes of both the owner and the driller. An understanding of just how yield and drawdown are related permits us to judge correctly what the figures from a pump test of a completed well really mean. Also, estimates of well performance can be made before the well is drilled by applying known relationships between drawdown and yield, provided certain other data about the characteristics of the aquifer are available.

Advance Studies Necessary

Many times plans are made for a development that requires given quantities of water even though the owner, engineer or driller do not know if this water can be obtained. Advance studies of the geology and the ground water possibilities of the area are a "must" during the initial planning. At this stage it is important, too, to determine the type of well construction that may best fit the existing geologic and hydrologic conditions. For maximum yield, then, the type of well to be drilled must be one which is suited to the situation and it must be constructed by the most scientific, up-to-date methods.

Not many persons are experienced in accurately estimating the yield of a well before it is drilled. Most drillers, however, do need to be able to use the values of the drawdown and yield, measured during a pumping test, to show the owner how the well will operate under varying conditions. When we consider the wide differences in types of water-bearing formations and the various types of wells that can be constructed to obtain water from them we see how important it is to know the basic principles that govern the yield of water wells.

Wells that obtain water from sand and gravel formations operate according to certain fundamental hydraulic principles. One of these is that water flows into the well from the surrounding aquifer because the pumping of the well creates a difference in pressure. Before pumping, the water in the well stands at a height equal to the static water level or static water pressure in the saturated sand around the well. When pumping starts, the water in the well is pulled down and water starts to flow into the well from the formation because the water level or pressure inside the well is now lower than it is in the aquifer outside the well. This pressure difference is the "drive" that causes the water to move through the pores of the sand toward the well.

What Is Drawdown?

The water flows through the sand from every direction and the closer it approaches the well the faster it moves. The lowering of the water level in the aquifer is everywhere in direct proportion to the velocity of flow. Thus, the lowered water surface has a continuously increasing downward slope toward the well. In form, this surface becomes an inverted, bell-shaped depression known as the "cone of depression." The amount that the water surface is lowered at any place in the formation and in the well itself is called the "drawdown" at that place.

Figure 1 shows how the drawdown is distributed over the zone of influence of a well. This curve represents the cone of depression of the water surface as the well is pumped at a constant rate. If the pumping rate is increased, the whole curve shifts down to a lower position and the drawdown increases at every point.

From the viewpoint of hydraulics, a water-bearing sand and gravel formation is a complex system of small passages filled with water. The interconnected voids or pores in the formation make up these irregular passages. To cause the water to flow in these openings from one point to another requires a difference in pressure or "head" between the two points. The difference in head divided by the distance between the two points is called the "hydraulic gradient" and we say that the water moves through the sand under the influence of the hydraulic gradient. Darcy, a French scientist who investigated the

Figure 1. Typical drawdown curve of a pumping well. The exact shape of the curve varies with each individual well; however, they are all similar and this one is representative of many.

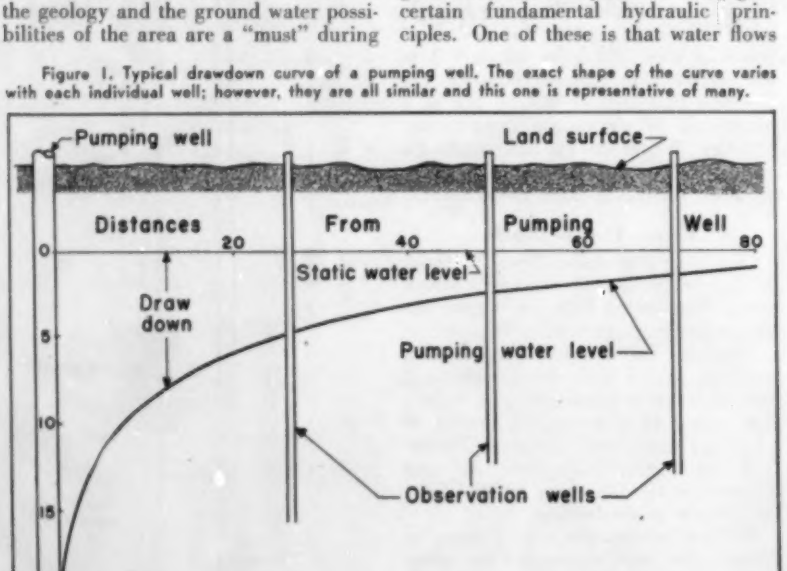


Fig. 1 -- Typical Drawdown Profile

flow of water through filter sands a hundred years ago, showed that the velocity through a given sand varies directly with the hydraulic gradient. If the hydraulic gradient (the difference in head per foot of travel) is doubled, the rate of flow is doubled. This principle is known as Darcy's law.

The term "head loss" is perhaps a more descriptive term for referring to the difference in head or pressure that is required to cause a certain rate of flow from one point to another in an aquifer, because it represents the force that is used up in overcoming the resistance to flow. Thus, if we want to double the rate of flow through the sand, then the head loss will also be doubled.

Referring again to Figure 1, the head losses from point to point along the water surface curve are the changes in drawdown between these points. Suppose, for example, the figures on the diagram represent distances in feet and the well is being pumped at a constant rate of 200 gpm. At a distance of 20 feet from the well the drawdown is five feet. This means that a head of five feet is required here to force 200 gpm to move thru the formation from the outer limit of the cone of depression up to within 20 feet of the well.

It takes another five feet of head to move the water at 200 gpm from the 20-foot distance up to within eight feet of the well. This makes the drawdown 10 feet at this point. The rest of the total drawdown or head loss, is used up in pushing the water through the last eight feet of sand and through the well screen.

Yield-Drawdown Relations

The total drawdown of 20 feet, then, represents the number of feet of head expended to cause 200 gpm to flow through the aquifer (within the zone of influence of the well) and through the screen. The shape of the drawdown curve shows that for a given yield the total drawdown is very sensitive to the conditions in the formation in the immediate vicinity of the well. Construction details can, therefore, affect the drawdown both favorably and unfavorably. This fact emphasizes the importance of using a well screen with maximum open area and of properly developing the formation surrounding the screen. These two factors reduce the head loss near the well and improve the efficiency of the well accordingly.

The foregoing explanation shows that yield and drawdown are inseparable factors in well performance. A given well yields different quantities of water at different values of drawdown. To say simply that a well yields 1,000 gpm presents an incomplete picture. To give the whole story, we must say that it yields 1,000 gpm at a drawdown of 40 feet.

Because of this interdependent relation of yield and drawdown, the yield per foot of drawdown is often employed as a measure of performance. This is called the "specific capacity" of the well. It is the yield divided by the drawdown. From the figures just given, the specific capacity is 1,000 divided by 40, or 25 gpm per foot of drawdown. Values of specific capacities permit us to compare the characteristics or efficiencies of different wells. For example, another well may deliver 1,000 gpm at a drawdown of 200 feet. Here the yield is the same as in the previous example but the specific capacity is only five gpm per foot of drawdown compared to 25. From the viewpoint of efficiency, the two wells perform far differently.

In addition to specific capacity as a measure of well performance, we are also often interested in the maximum theoretical yield of a well and, above all, its maximum practical yield. The maximum theoretical yield is attained at maximum drawdown — that is, when the pumping level is pulled down to the bottom of the well. Obviously, practical considerations do not permit wells to be operated at maximum drawdown.* The lowest practical pumping level and the practical limit of drawdown depend upon certain features of the well design or construction. For very deep wells, the pumping level may depend upon the mechanical limitations of the pumping equipment. The maximum *practical* yield of a given well, therefore, is the yield at the *practical* limit of drawdown. This should be thought of as the "available drawdown," since it is that part of the total head of water in the well that can be utilized.

Available Drawdown

Generally speaking, the pumping level in a well completed in a sand formation should be kept above the top of the well screen. If a well screen with maximum inlet area and proper length is installed, the well will operate best within this limit of drawdown. As an example, if the depth to static water level is 30 feet and depth to the top of the well screen is 90 feet, the available drawdown is 60 feet. Or, if the standing depth of water in a well is 80 feet and the well screen is 20 feet long, the available drawdown is 60 feet.

Pulling the water down below the top

*Some irrigation wells do have their pumps set as near to full depth as possible and operate with pumping levels only a few feet above bottom. Whereas this practice can be tolerated under some conditions in irrigation wells that are pumped only two or three months per year, the drawdown in the vast majority of wells cannot be carried to this extreme.

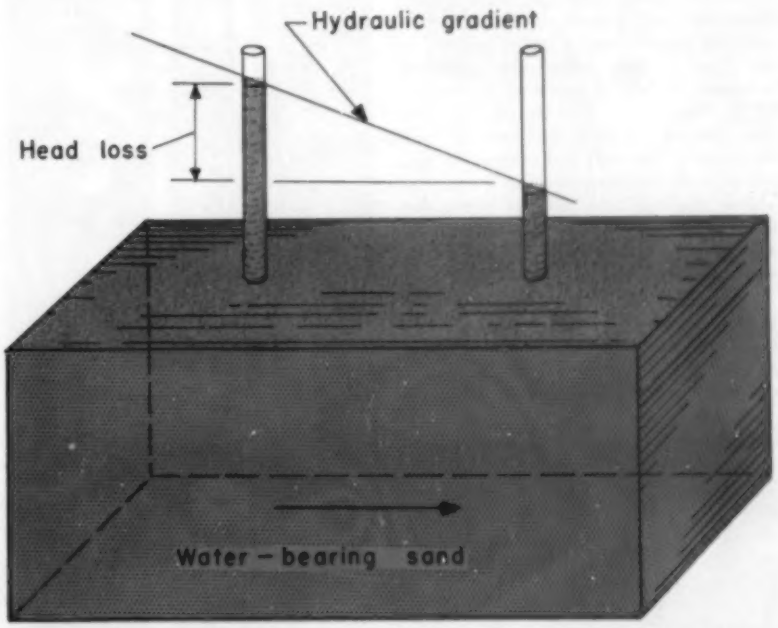


Figure 2. Diagram illustrating head loss and hydraulic gradient which must prevail to cause flow through a sand formation. For a given sand, the rate of flow is directly proportional to the hydraulic gradient.

of the screen dewaters just that much of the screen. The dewatered section no longer contributes anything to the yield of the well. Part of the formation immediately surrounding the screen is also dewatered which means that the total flow into the well must pass through a reduced thickness of sand. The velocities in this thinner section of saturated sand increase out of proportion to the increase in yield, usually resulting in a sharp drop in specific capacity when the reduction in saturated thickness occurs. For very practical reasons, therefore, the available drawdown in a screened well is the distance from the static water level to the top of the well screen.

This view may be contradicted by some who use perforated pipe or other substitutes in place of properly designed well screens. They may have observed little change in such wells when the water level is pulled down inside the perforated section of the casing. The explanation for this observation lies in the fact that, in most cases, the inlet area of the perforated pipe is too little to admit the full yield of the formation to the well at reasonable velocities of flow. Extra drawdown is then required to develop higher inlet velocities. It is not uncommon in such cases to see streams of water spurting through the perforations several feet above the pumping level.

Factors Affecting Yield

Before continuing in more detail about the yield-drawdown relation under varying conditions, a brief review of the factors that affect the yield of screened wells will serve as an outline of the discussion. The list of these factors includes certain elements of construction of the well and certain characteristics of the water-bearing formation. Taken together they are the items that must be considered in designing a well, selecting the well screen and estimating the well capacity.

Particle size. Coarse sands and gravels have large pores and thus offer less resistance to flow than do the finer sands. Other things being equal, the coarser materials give higher yield.

Uniformity of grading. Sand particles all about the same size make a uniformly graded material. Mixtures of fine and coarse particles are non-uniformly graded. The more uniform the grading of a sand, of a given average size, the greater will be its porosity. High porosity decreases resistance to flow and increases yield.

Silt and Clay. When these fine particles are found mixed with sand and gravel they partially block the pores of the formation. Under such conditions, the yielding ability of the formation is low.

Cementation. A cementing material may partially fill the openings in a sand and may cut off some of the passages so that the pores are not completely interconnected. The lower porosity of such a formation means less yield.

Thickness of aquifer. Other things being equal, a sand aquifer yields water to wells in proportion to its thickness. It's like a pipe — the larger it is, the more water can move through it. The thicker the aquifer, the more water it will carry.

Assembling 12-inch Johnson Stainless Steel Well Screen, 25 feet long, preparatory to setting in a 16-inch well for the Beloit Iron Works. The screen is No. 80 slot. The well was carefully developed and it pumped 800 gpm with 16 feet drawdown on test. Drilling contractor is Allabaugh Well Co. of Rockford, Illinois.

Stratification of aquifer. If an aquifer consists of a layer of sand underlaid by a layer of gravel, it will yield differently than either of the two materials alone and differently than a mixture of the two materials. Also, sand layers are often separated by thin streaks of clay. These cut off free movement of water from the upper sand into the lower one.

Diameter of well. The yield of a well increases some as its diameter is made larger, but not in direct proportion to its diameter. Doubling the diameter will increase yield about 15 per cent.

Length of screen. The length of well screen as compared to the thickness of the aquifer greatly affects the yield of the well. Both total thickness and thicknesses of various layers within the aquifer must be carefully considered in choosing the proper length of screen.

Available drawdown. In addition to the effect of well depth and screen length on this factor, available drawdown also changes as the static level may be raised or lowered by outside influences. Interference from other nearby pumped wells reduces available drawdown.

Recharge to aquifer. If the water-bearing formation receives no recharge to replace the water being pumped, the drawdown will increase as long as pumping continues. The pumping level and drawdown will become stable only if there is recharge to the formation within the zone of influence of the well.

Hydraulic boundaries. If the aquifer pinches out or is cut off by a clay or rock wall within the zone of influence of the well, the yield of the well will be less than if the aquifer were continuous in every direction.

Well Development. The way in which the well is drilled and developed has an important bearing on its yield and efficiency. Whether the well should be artificially gravel-packed or naturally developed, depends upon several considerations.

Open area of screen. Maximum open area per foot of screen insures minimum velocity through the screen openings, minimum head loss through the screen and consequently less drawdown. The size of screen openings should be carefully selected to fit the grading of the sand or gravel surrounding the screen.

(Part II of this article will discuss some of these factors in detail. It will appear in the September-October issue of the JOURNAL.)

ASSOCIATION NEWS

This section is devoted to the exclusive use of water well drillers' associations, both state and local. Notices, announcements, changes of officers and other items should be sent to The Editor, Johnson National Drillers' Journal, 2306 Long Ave., St. Paul 14, Minnesota.

New York

The summer meeting of the Empire State Water Well Drillers' Association was held on July 16 at Babylon on Long Island. A fine crowd attended. The principal item of business discussed at the meeting was the preparation of a code of ethics for drilling contractors in New York. A committee was appointed to prepare a draft of such a code for full consideration by the membership of the association.

A majority of the members who journeyed to Babylon stayed over another day and enjoyed some deep-sea fishing in the Atlantic Ocean.

The October meeting of the association will be held in Jamestown, New York. The exact date and place will be announced later.

Virginia

The meeting of the Virginia Water Well Drillers Association at Roanoke on May 21 was attended by 143 persons and much enjoyed. The principal speaker was Robert Denny, who emphasized in a number of unique ways the importance of skillful well drilling contractors in developing ground water supplies. One session of the meeting was devoted to a discussion by members, jobbers and manufacturers of ideas to better the industry and develop a better appreciation of the drilling contractors' responsibilities. Visitors from Maryland, North Carolina and Ohio were present.

At the conclusion of the general meeting, the board of directors discussed plans for the annual meeting. It was decided to hold the annual meeting and election of new directors and officers on September 21 at the William Byrd Hotel in Richmond. It is hoped that every member of the association will attend in September.

Indiana

Making plans well in advance, the Indiana Well Drilling Contractors Association has set January 19 and 20 as the dates for its 1956 convention. The meeting will be held in the Hotel Van Orman in Fort Wayne.

The association now has the largest membership in its history. The association gained much prestige in the last session of the Indiana State Legislature when it represented the interests of water well drilling contractors in hearings on proposed ground water legislation. Drillers who are not already members should lend their support by sending their membership dues to R. T. Hill, secretary, LaFontaine.

Ontario, Canada

More than 160 drillers and 56 ladies registered attendance at the annual meeting of the Ontario Water Well Association held in Oakville on May 5 and 6. A group of good exhibits, including several drilling machines, attracted much attention from all of the drillers present. The program included a good series of technical talks and there were plenty of social events to satisfy everyone.

At the final business meeting Carl Laramie of Kingsville was elected president; Douglas McLean of Ottawa was elected vice president, and Earl Hernandez of Harrow was elected secretary-treasurer. In addition to the officers, the board of directors for this year includes R. H. Casselman of Williamsburg, W. H. Davy of Verona, J. B. Longstreet of Matheson, Wes Huffman of Mimico, Don Jacobson of Port Credit, Neil Hopper of Seaforth, Ellis McLaughlin of Waterloo and Charles Warren of Blenheim.

Activities of the association have increased the paid up membership to 104 drilling contractors. There are also some 40 associate members of the organization. Although the association is still young, it is performing a real service for the drilling contractors of Ontario and deserves the active support of every one of them.

Mississippi

The semi-annual meeting of the Mississippi Water Well Contractors Association, held in Jackson on June 10, was a great success. The meeting was largely

Installing 12-inch Johnson Everdur Well Screen, 35 feet long, with No. 60 slot openings, in a well for a large automobile proving ground. The completed well was tested at 700 gpm with 26 feet drawdown. O. O. Corsaut Co. of Oak Park, Michigan, is the drilling contractor.

a social event, but it afforded an excellent opportunity for drilling contractors all over the state to get better acquainted with each other and to get a better understanding of the drilling problems faced by fellow members. Another meeting is planned for September at which time new officers will be elected, and other business of the association conducted. The September meeting will also include several social events.

One interesting and unusual feature of the meeting at Jackson was a well bidding contest. Each driller was told to turn in a bid according to a complete specification for a well, pump, motor and tank. A judging committee of three drillers also figured the job and took the average of their three estimates as the correct bid. The closest figure to the committee bid was turned in by J. C. Reeves of Amory, for the first prize in the contest.

Colorado

The mid-year meeting of the Colorado Water Well Contractors Association at Estes Park lived up to every expectation. A good crowd was on hand, important business was taken care of and everyone had a good time.

Contributions and pledges to continue the executive secretary's office through November were made. Dues for next year that will be coming in at the annual convention are expected to take care of the costs from that date on. A new scale of annual dues was adopted which is graduated according to members' gross sales. The minimum is $35 per year for a driller with less than $5,000 gross and goes up to $1,000 per year for a firm with $500,000 gross sales.

The next meeting will be the big convention on November 3, 4 and 5 at the Shirley Savoy Hotel in Denver.

Idaho

The beautiful setting of Payette Lake made McCall an ideal place for the eighth annual convention of the Idaho Drillers' Association which took place on June 27 and 28. More than 120 persons registered for the convention. The two-day program included interesting and informative discussions on subjects of interest to Idaho drilling contractors. The convention committee, headed by Clifford Hosack, did a fine job in organizing both the program and the social events of the convention.

At the business meeting the executive secretary, W. B. Bowler, outlined the activities and progress of the association during the past year. He pointed out that the organization was in a healthy condition and enjoyed the respect of the various state agencies that have responsibilities for the control and conservation of ground water in Idaho. He said that free discussion of drilling costs and prices should be encouraged, not for the purpose of price fixing but to raise prices to a level equal to what the work is worth.

New directors of the association elected at the business meeting include: Verl Andrew of Idaho Falls, Blaine Boley of Murtaugh, Orval Harden of Boise, and Sterling Sigman of Pocatello. Officers elected for the coming year are: Charles Cope of Idaho Falls, president; Clifford Hosack of Nampa, first vice-president; Verl Andrew of Idaho Falls, second vice-president; W. B. Bowler, attorney from Boise, secretary-treasurer.

Oklahoma

October 27 and 28 are the dates for the 1955 convention of the Oklahoma Water Well Drillers' Association. Enid has been selected again as the convention city. The municipal auditorium will house the indoor exhibits of equipment and materials. Drilling machines will be demonstrated in the outdoor exhibit space across the street. Last year's meeting was outstanding — the committee says the 1955 show will be even better.

New Well Seal

A new well seal made of steel plate and a heavy rubber ring is announced by its originator, Robert R. Thompson of Marshall, Missouri. Called the Thompson Seal, it is made for all sizes of casing and provides any type connections for pumping equipment.

According to Mr. Thompson, the seal will support heavy reciprocating pumps,

Thompson Seal consists of steel disc welded to steel ring, heavy rubber gasket, and flange welded to well casing.

as well as jet-type and submersible pumps. He also says the seal is airtight. When the pumping lowers the water level in the well, it creates a partial vacuum inside the casing which sometimes improves the well yield.

Weekends

★ ★ ★

MAKE THEM SAFE

Practically all of us look forward to the weekend as a time for rest and pleasure. We can catch up on our golf game, work around the house and have some fun with the children. It's the time for going to church, watching television, listening to the ball game or visiting or being visited by friends.

The weekends are all of those things — except on the highways. In 1953, 15,800 persons were killed and 800,000 were injured in weekend accidents, according to figures compiled and recently released by The Travelers Insurance Companies. Forty-one per cent of the deaths and 36 per cent of the injuries were recorded on Saturdays and Sundays in 1953.

"I found I couldn't walk, so I was forced to drive."

Saturday continued to be the most dangerous day of the week. One reason is that more cars are in use Saturday than on any weekday. There is another distinguishing feature which sets this day apart from the others. For too many people, Saturday night is a time when drinking and driving combine. No one knows exactly how many traffic accidents are caused by drinking drivers but everyone knows it is a major problem. Everyone needs to know that even one drink before driving is too many.

Weekends indeed are a time of rest. For too many they are the beginnings of *permanent* rest.

Water for Fun!

In a state — known far and wide as "The Land of 10,000 Lakes" — where tourism ranks with such other great industries as iron ore mining and agriculture, Minneapolis for the last 16 years has done its share in "selling" Minnesota through the thrilling, fun-packed Aquatennial.

The pictures on this page will only begin to suggest the scope and variety of this mammoth, water-centered, 10-day celebration.

The "City of Lakes" (there are 22 within the city limits) really lives up to its name in this annual spectacle. Drillers especially will be aware of all the water that backgrounds the Aquatennial. They also will be interested to know that there is a great deal more ground water under Minneapolis than is to be found in all her lakes!

Photos Courtesy Minneapolis Tribune

ADVERTISEMENTS

We will insert advertisements for drilling equipment wanted or for sale, help or work wanted, etc., for our readers, free of charge. Advertisements must be brief, and we cannot assume responsibility for them, but will be glad to put parties in touch with each other by this means and suggest that they investigate any offers or inquiries carefully for themselves.

WANT TO BUY: From 250 to 350 feet 2⅜" or 2⅞" drill pipe in 10½' joints with exploration or upset tool joints. Give full information on condition and price. Cleo Anderson, Selden, Kansas.

WANT TO TRADE: All-steel Keystone drill in good condition, with 6" tools and lines, mounted on 3-ton 10-wheel truck. Want No. 6 Ideco or No. 35 Cyclone drill. Photographs and description on request. E. L. Graves, Box 225, Sylacauga, Alabama. (Phone 2-4213).

FOR SALE: No. 71 Star drill, four months old, mounted on 1946 Dodge truck. New tools, fully equipped. E. L. Beck, 7631 Lowell, Overland Park, Kansas, (Phone Niagara 2310).

FOR SALE: Complete shop-built rotary drill, trailer mounted, in first-class condition. Has 32' steel mast; practically new pumps and new water tank. Equipped with 2⅝" drill pipe with tool joints, bits from 5" to 30", all sizes bailers. Now operating but selling because of health. Price $4,000. S. J. Catlett, 2408 Main, Woodward, Oklahoma. (Phone 797J).

FOR SALE: Two No. 71 speed Star drills, one No. 72 and one No. 83 Star drill with or without tools. Complete rotary attachment and 1,500' drill pipe for No. 72 and No. 83 machines. Jackson-Markus Supply Co., 3612 East 26th St., Los Angeles, California.

FOR SALE: Cyclone drilling machine, all steel, converted to wire line with shock absorber in mast; mounted on 2-ton 1947 Diamond T truck; new International Harvester engine. Excellent condition. Price $1,500. Albert R. Minor, P. O. Box 2119, Columbus, Ohio. (Phone Klondike 3711).

FOR SALE: No. 40 Keystone drill, all steel, with 6 cyl. Ford engine; transmission and V-belt drive; telescoping mast; mounted on 1½-ton 1944 Ford truck. Can be made into excellent machine with some repairs. Price $1,000. Albert R. Minor, P. O. Box 2119, Columbus, Ohio. (Phone Klondike 3711).

FOR SALE: Complete well drilling business. Includes 1953 Model 22-W drill on good 2-ton 1950 Chevrolet truck; trailer; tools, tool boxes, bailers and lots of bits. Everything for drilling and pump business. Good location. Selling due to health. Bob Evans, Box 701, Sidney, Montana.

FOR SALE: New Peerless 3 x 4 x 12 irrigation pump with Waukesha XAHU gasoline engine and accessories; 3" Crane valve and companion flanges; skid-mounted. Pump rated 650 gpm at 80 psi; engine 40 bhp max. weight about 1,200 lbs. Price $1,000, f.o.b. Hartford, Connecticut. Olds & Whipple, Inc., 168 State Street, Hartford, Connecticut.

FOR SALE: New Rex 10M contractor's pump, with Wisconsin AEH engine, mounted on two-wheel truck. No hoses. Weight about 370 lbs. Price $250 f.o.b. Hartford, Connecticut. Olds & Whipple, Inc., 168 State Street, Hartford.

WANT TO BUY: Failing 1500 rotary dirll with high derrick and 500 feet 2⅞" drill rod. Also want B-E 20W or 55 Star cable tool drill. Elmer Crain, Boyne City, Michigan.

FOR SALE: Drilling business including three cable tool machines, with tools, mounted on trucks. Four arc and two acetylene welders; service trucks; home-made house trailer. Large inventory supplies. Gross $20,000 to $35,000 yearly. Price, $15,000 cash. Write for details. Gust R. Lagerquist, Westby, Montana.

WANT TO BUY: Used rotary drill with 5 x 6 or larger pump. Hedges Drilling Co., R. F. D. 6, Lincoln, Nebraska.

FOR SALE: No. 50 Keystone drilling machine, all steel, 1941 model. In good shape. Price, less tools and truck, $2,000. Columbia Pump and Well Co., 11018 Kemp Mill Road, Silver Spring, Maryland.

FOR SALE: Sparta machine, wood frame, rubber tires, 4-cyl. Dodge engine; 350' new ⅝" drill cable, 350' of ⅜" sand line. Three stems, 3 sets drilling jars, 8 bits, 2 bailers and other tools. Price $500. Mrs. Chas. Dunst, Route 1, Coleman, Wisconsin.

FOR SALE: No. 240 Star drill on 1941 Chevrolet truck, with 800' drill cable and sand line. All necessary tools for 4" wells. All in A-1 condition. Machine now working. Price $2,500. Rayburn and Martin, 121 West Sumner, Indianapolis, Indiana. (Phone GA 5497 or BL 0133).

WANTED: Driller who is familiar with setting Johnson screens and developing screened wells. Also, driller for deeper rock wells. Douglas Holzem, Beloit, Wisconsin.

FOR SALE: One 12-inch bit, almost new, joint 2¾ x 3¾ API: 4-inch square; 800 pounds. John Hamilton, Ellsworth, Wisconsin.

WANT TO BUY: Good used drilling machine complete with tools for 4-inch and 6-inch wells. L. F. Coleman, Wheeling, Missouri.

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FOR SALE: No. 240 Speed Star, 1947 model, mounted on 1½-ton truck; with cables and string of 4" tools. Price $1,500. Jerome Primus, 1023 14th Ave. SE, St. Cloud, Minnesota.

WANTED: Used, truck-mounted, cable-tool drill with steel frame. Prefer shock absorber and winches for pulling pipe. Need 4" to 6" capacity with or without tools and lines. Mr. M. D. Love, Emerald, Wisconsin.

FOR SALE: No. 42 Cyclone drill, all steel, mounted on 1946 Studebaker; tools and 600 lines; $3,700. All steel machine on 1946 Studebaker with 6" tools and lines, $1,200. Failing 1500 rotary on 1954 International 170; tools and drill pipe, $17,500. Caterpillar motor patrol, $500. Four-inch centrifugal pump, $200. Circle jack, $65. Herschel Mourning, Colchester, Illinois.

POSITION WANTED: Married, Dutch, 29 years old, experienced cable-tool water well driller, Ruston-Bucyrus 22-W outfits. Sober, careful and able to drill without supervision. Want permanent job any place, but subtropical and tropical countries preferred. Worked Indonesia (the former Dutch East Indies) and Africa. At present in Holland. Harry A. van Aken c/o Edward E. Johnson, Inc., 2304 Long Avenue, St. Paul 14, Minnesota.

FOR SALE: Model L, Fort Worth spudder, practically new; mounted on semi-trailer; Waukesha engine; tools for 5" and 6" holes. Includes 500' each of ⅝" and ⅜" lines. 1947 Chevrolet tractor. New 350 gal. water tank; 1946 Ford flat-bed truck; other miscellaneous items. Price $4,500. J. R. Farmer, 2214 Loving Road, Graham, Texas.

WANTED: Man experienced with deep-well turbines and water systems needed by long-established company in southeastern Michigan. Give age, experience and qualifications. Excellent salary for right man. Box MIC, c/o Edward E. Johnson, Inc., 2304 Long Avenue, St. Paul 14, Minnesota.

FOR SALE: Model 35 Armstrong drilling machine, trailer mounted (6.00x20 Budd wheels) with 1941 Ford flat-bed truck. Includes ⅝" cable and 2x3-7 API tool joints. Price $1,975. Oasis Drilling Contractors, 225 W. Main, Waukesha, Wisconsin. Phone: Liberty 7-3514.

FOR SALE: Truck-mounted rotary drills. Mayhew 1000—$5,250; Failing 750—$5,500; Failing 1500, Sullivan 200 A; Failing 1000 A —$4,500. Fred E. Butler, Box 481, Pueblo, Colorado.

DRILLER WANTED: Cable-tool or rotary operator to drill water wells on commission. Herschel Mourning, Colchester, Illinois.

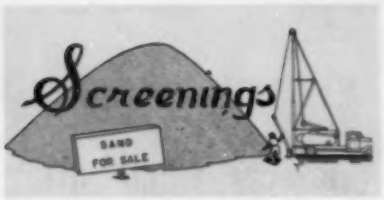
FOR SALE: Model 21-W Bucyrus-Erie drill on Ford truck. O. E. Lewis, Darlington, Indiana.

FOR SALE: Cyclone 35 drill, 1954 model, truck mounted. String of 4" tools, 250' drilling and sand lines, hand tools. Reasonable price. Everett Justin, Box 86, Boody, Illinois. Phone Elwin 2115.

FOR SALE: 21-W Bucyrus-Erie drill, 1946 model, mounted on 1941 International truck. Catheads, 500' of new ⅝" cable, 500' of ⅜" cable. Price $2,000 cash. Austin Wittlief, R.F.D. Two Harbors, Minnesota.

FOR SALE: Winter-Weiss, reverse-circulation drilling machine, 1954 model, on semi-trailer with 1954 Ford F-600 tractor. Complete with drill bits, 150' of drill stem and spare parts. Excellent condition — ready to drill. Write Box V D C c/o Edward E. Johnson, Inc., 2304 Long Avenue, St. Paul 14, Minnesota.

FOR SALE: Two 21-W Bucyrus-Erie drills, 1948 model; one mounted on International truck, other on GMC driven only 14,000 miles.



Judge: "Aren't you ashamed to have your wife support you by taking in washing?"

Guilty One: "Yes, I am, your Honor. But what can I do? She's too ignorant to do anything better."

Two farmers met in town after one of the recent tornadoes.

"Shore did a lot of damage out our way," said one reflectively. "By the way, Hank, did it damage that new barn of yours?"

"Can't rightly say," Hank answered, slowly shifting his wad of chew from one cheek to t'other. "Ain't found it yet."

"He seems to have a very good opinion of himself."

"Yes. On his last birthday he sent his parents a telegram of congratulation."

The will has just been probated of a man living in a southwest suburb of London who died last November, in which he left to his wife: "One pair of my trousers, free of duty, and carriage paid, as a symbol of what she wanted to wear in my lifetime, but did not."

Accompanist — "Madam, I've played on the white keys and I've played on the black keys, but why must you always sing in the cracks?"

The difference between amnesia and magnesia is that the fellow with amnesia can't remember where he's going.

Derrick on four-wheel trailer for installing and pulling pumps. Built by Edw. E. Briggs, drilling contractor, Advance, Missouri.

Both machines in good condition, complete with cable but no tools. Lindsay Bros. Company, 422 North First Street, Minneapolis, Minnesota.

FOR SALE: Bucyrus-Erie 21-W drill, 1947 model, mounted on 1½ ton 1941 Dodge truck. Has cathead, 500 feet ⅝" drill line, 350 feet ⅜" sand line. Price $2,250. John R. Johnson, Cokato, Minnesota.

FOR SALE: Well machine like Howell No. 60, band-wheel type, trailer mounted; all steel construction. Charles Minett, Russell, Minnesota.

FOR SALE: Bucyrus-Erie 21-W drilling machine with Allis-Chalmers power unit, mounted on 1½-ton 1946 GMC truck. Has one cathead, and 500' each, ⅝" cable and ⅜" sand line. Clarence Heil, Brownton, Minnesota.

FOR SALE: Model 21-W drill mounted on 1½ ton 1946 Chevrolet truck. Has over 500' of ⅝" cable and equipped with catheads. E. W. Geib Well Company, Arlington, Minnesota.

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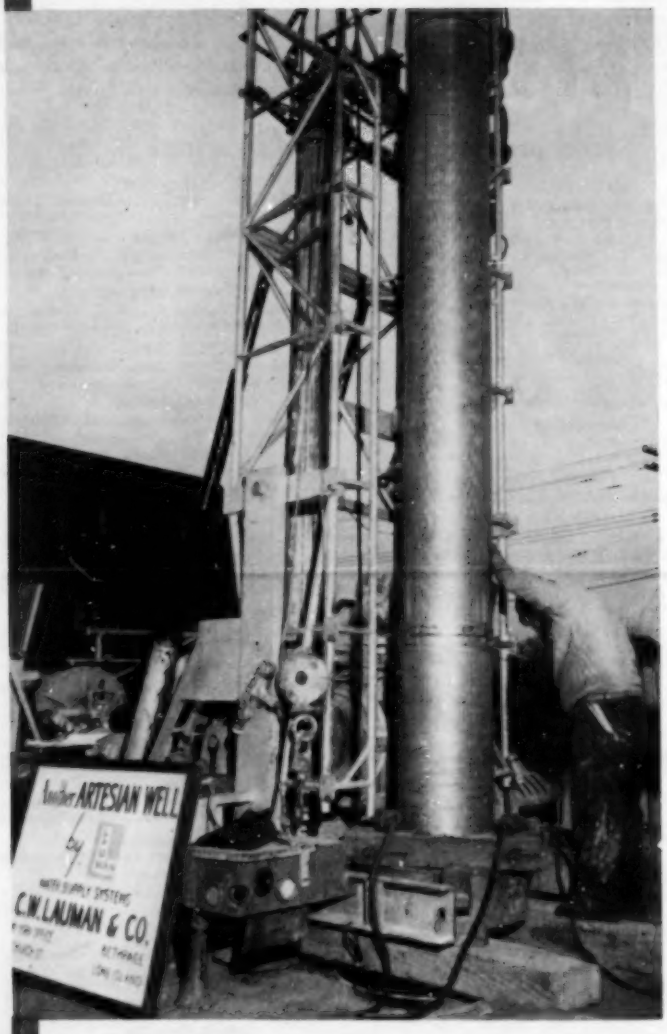

Johnson Well Screens

The well screen is the "business end" of the well. The design of Johnson Well Screens and the careful selection of the proper screen for each job insures capacity up to the limit of the water-bearing vein.

Johnson Well Screens are custom-made for each installation.

Johnson Stainless Steel Well Screen being installed in well that delivers over three million gallons per day of crystal-clear water.

- ***A POOR WELL IS A BAD INVESTMENT***
- ***A GOOD WELL SAVES MONEY EVERY YEAR***

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